

What is claimed is:

1. A method of making an n-type semiconductor diamond, characterized in that it comprises:

5 mechanically polishing a diamond substrate to make it an inclined diamond substrate;

subjecting a surface of said inclined diamond substrate to a smoothening treatment to make the surface even;

10 exciting a raw material gas made of a volatile hydrocarbon compound, a sulfur compound and a hydrogen gas by a microwave plasma while maintaining at a given temperature said diamond substrate surface smoothened as aforesaid to cause n-type semiconductor diamond to grow epitaxially on said surface smoothened substrate.

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2. A method of making an n-type semiconductor diamond as set forth in claim 1, characterized in that said diamond substrate comprises a diamond (100) face oriented substrate.

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3. A method of making an n-type semiconductor diamond as set forth in claim 1, characterized in that said inclined substrate is formed by mechanically polishing a diamond (100) face oriented substrate surface so that its face normal is inclined at an angle in a range between 1.5 degree and 6 degrees with respect to its <100> direction in a plane made by either its <100> and <010> directions or its <100> and <001> directions.

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4. A method of making an n-type semiconductor diamond as set forth in claim 1, characterized in that said smoothening treatment comprises either a treatment in which said inclined substrate is exposed to a hydrogen plasma or a treatment in which it is exposed to an oxidizing flame such as an acetylene combustion flame.

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5. A method of making an n-type semiconductor diamond as set forth in claim 1, characterized in that said hydrogen plasma exposure treatment comprises a treatment of exposing said inclined substrate to the hydrogen plasma of a hydrogen pressure of 10 to 50 Torr and a microwave output of 200 to 1200 W at a substrate temperature of 700 to 1200°C for a period of 0.5 hour to 5 hours.

6. A method of making an n-type semiconductor diamond as set forth in claim 1, characterized in that said given substrate temperature lies in a range between 700 and 1100°C, preferably at 830°C.

7. A method of making an n-type semiconductor diamond as set forth in claim 1, characterized in that said volatile hydrocarbon compound is an alkane or an alkene.

8. A method of making an n-type semiconductor diamond as set forth in claim 7, characterized in that said alkane is methane, ethane or propane.

9. A method of making an n-type semiconductor diamond as set forth in claim 7, characterized in that said alkene is ethylene or propylene.

10. A method of making an n-type semiconductor diamond as set forth in claim 1, characterized in that said sulfur compound is hydrogen sulfide or carbon disulfide.

11. A method of making an n-type semiconductor diamond as set forth in claim 1, characterized in that said sulfur compound is an organic sulfur compound.

12. A method of making an n-type semiconductor diamond as set forth in claim 11, characterized in that said organic sulfur compound is lower alkyl mercaptan.

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13. A method of making an n-type semiconductor diamond as set forth in claim 1, characterized in that said raw material gas is made of methane of a concentration of 0.1 % to 5 %, hydrogen sulfide of a concentration of 1 ppm to 2000 ppm and hydrogen and, while being drawn at a rate of flow of  $200 \text{ ml} \cdot \text{min}^{-1}$  under a pressure of 30 to 60 Torr, it is excited by said microwave plasma having a microwave frequency of 2.45 GHz and a microwave output of 300 to 400 W.

14. An n-type semiconductor diamond made by a method of making an n-type semiconductor material set forth in any one of claims 1 to 13.

15. An n-type semiconductor diamond as set forth in claim 14, characterized in that it has impurity atoms comprising sulfur atoms forming a donor level of 0.38 eV.

16. An n-type semiconductor diamond as set forth in claim 14, characterized in that it has a carrier mobility's temperature dependency which at a temperature  $T$  in excess of the room temperature is  $T^{-3/2}$  dependent.

17. An n-type semiconductor diamond as set forth in claim 14, characterized in that a light emission by free and a light emission by bound excitons are observable.

18. An n-type semiconductor diamond as set forth in claim 14,

~~characterized in that at a room temperature it has a carrier concentration not less than  $1.4 \times 10^{13} \text{ cm}^{-3}$  and a carrier mobility not less than  $580 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ .~~

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What is claimed is:

1. (As amended) An n-type semiconductor diamond, characterized by:

5 a crystalline perfectness whereby:

it has impurity atoms constituted by sulfur atoms forming a single donor level of 0.38 eV,

10 it has a carrier mobility's temperature dependency which at a temperature (T) range in excess of the room temperature is  $T^{-3/2}$  dependent, and

it has a diamond peak in its Raman spectrum, whose half width is  $2.6 \text{ cm}^{-1}$ ;

a crystalline perfectness whereby:

light emission by excitons is observable; and

15 a crystalline perfectness whereby:

a distinct Kikuchi pattern in its reflection electron diffraction analysis is observable.

20 2. (As amended) An n-type semiconductor diamond as set forth in claim 1, characterized in that at a room temperature it has a carrier concentration not less than  $1.4 \times 10^{13} \text{ cm}^{-3}$  and a carrier mobility not less than  $580 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ .

25 3. (As amended) A method of making an n-type semiconductor diamond, characterized in that it comprises:

mechanically polishing a diamond substrate to make it an inclined diamond substrate;

subjecting a surface of said inclined diamond substrate to a smoothening treatment make it even;

30 exciting a raw material gas made of a volatile hydrocarbon compound, a sulfur compound and a hydrogen gas by a microwave plasma while maintaining at a given temperature said substrate

surface smoothened as aforesaid to cause n-type semiconductor diamond to grow epitaxially on said surface smoothened substrate.

4. (As amended) A method of making an n-type semiconductor diamond as set forth in claim 3, characterized in that said diamond substrate is a diamond (100) face oriented substrate.

5. (As amended) A method of making an n-type semiconductor diamond as set forth in claim 3, characterized in that said inclined substrate is formed to consist of steps each in the order of an atomic layer, by mechanically polishing a diamond (100) face oriented substrate so that its face normal is inclined at an angle in a range between 1.5 degree and 6 degrees with respect to its  $\langle 100 \rangle$  direction in a plane made by either its  $\langle 100 \rangle$  and  $\langle 010 \rangle$  directions or its  $\langle 100 \rangle$  and  $\langle 001 \rangle$  directions.

6. (As amended) A method of making an n-type semiconductor diamond as set forth in claim 3, characterized in that said hydrogen plasma exposure treatment comprises a treatment of exposing said inclined substrate to the hydrogen plasma of a hydrogen pressure of 10 to 50 Torr and a microwave output of 200 to 1200 W at a substrate temperature of 700 to 1200°C for a period of 0.5 hour to 5 hours, thereby to make even said substrate surface in the order of an atomic layer.

7. (As amended) A method of making an n-type semiconductor diamond as set forth in claim 3, characterized in that said given substrate temperature lies in a range between 700 and 1100°C, preferably at 830°C.

8.~19. (As deleted)